

FILTER ASSEMBLY

The invention relates to filter assemblies.

5 A known form of filter assembly comprises a housing providing an inlet port and an outlet port with a filter element being held in the housing and comprising a filter medium having a central passage extending between first and second ends of the filter medium. The first end of the filter medium is connected to an end cap to close the passage and the second end of the filter medium is in fluid communication with a port of the housing.

10 In this way, fluid passing to the housing flows through the filter medium in a path including the inlet port, the outlet port and the passage. Such filters are used extensively for medical, biomedical and pharmaceutical purposes.

15 It is a requirement of such filter assemblies that the filter element must be capable of being integrity tested. For water-wettable filter media integrity can be tested by the Water Bubble Point Test or the Diffusive Forward Flow Test. In the Water Bubble Point Test, the filter element is placed in a water bath with both the first and second ends of the passage closed and air is pumped into the passage at a pressure which

20

25

is increased until the first bubble is observed on the exterior of the filter medium. If the structure of the filter medium has integrity over its whole volume, this first bubble will appear at a predetermined pressure. If a bubble or bubbles appear at a lower pressure, it is an indication that the structure of the filter medium is not uniform over the whole volume of the filter medium. This can indicate the incidence of passages through the filter medium which might allow the passage through the medium in use of unfiltered or only partly filtered fluid.

In the Diffusive Forward Flow Test, the filter medium is wetted with water and surplus water is removed. Air is applied to one side of the medium at a specified pressure and the diffusive air flow rate is measured. This diffusive air flow rate has been found to be related to the removal rating of the medium. A greater than expected flow rate can indicate lack of integrity of the medium.

However, the connection to a water-wettable filter medium of an end cap can change the characteristics of the medium so that integrity testing is no longer possible. For example, the connection can produce hydrophobic zones in the medium which do not wet out in the integrity test and thus plainly affect the performance of the medium in the integrity test.

For this reason, the materials of the filter medium and the end cap are usually chosen so that connection of the medium and the end cap does not affect the characteristics of the medium in a manner that would affect the medium's performance in an integrity test.

The material of the end cap is also important for hydrophobic filter media. Some hydrophobic filter media are easily damaged by heat. These media are attached to the end cap by heating the end cap to soften the end cap and inserting the first end of the medium into the end cap while the end cap is softened. It is therefore important to choose a material for the end cap that softens at a relatively low temperature such that the connection can be carried out without damaging the media.

However, it is also a requirement for such filter assemblies that have medical, biomedical and pharmaceutical uses that they can be sterilized to allow for repeated use. There are two principal forms of sterilization; in situ steam sterilization and steam autoclaving. In in situ steam sterilization, instead of fluid to be filtered passing to the filter assembly, high pressure and high temperature steam are passed through the filter assembly. For example, the steam pressure may be several bars and the temperature 140°C. In


steam autoclaving, the filter assembly is removed from associated equipment and transferred to an autoclave where it is steam sterilized. The filter assembly is then removed from the autoclave, transferred aseptically and replaced in the equipment. A typical filter assembly might need sterilizing 100 times in its lifetime.

Where the housing of such a filter assembly is made of a plastics material, the second end of the filter medium is usually connected to the housing by heating the housing material and inserting the second end of the filter medium into the housing material. For water-wettable media, in order to produce a water wettable joint for integrity testing purposes, it is thus necessary to have the housing of an appropriate material that produces the required joint. For hydrophobic media that are relatively easily damaged by heat it is necessary for the plastics material of the housing to have a relatively low softening temperature. Such plastics materials are not able to withstand the pressures and temperatures of in situ steam sterilization. Accordingly, such filter assemblies must be sterilized by autoclaving. This requires the filter assembly to be removed from service, autoclaved and then transferred aseptically back into service.

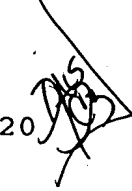
The known alternative is to house the filter element in a metal housing. The metal will withstand the temperatures and pressures of in situ steam sterilization but metal housings are typically much bulkier than plastics housings and are more expensive to produce and require cleaning before re-use.

According to a first aspect of the invention, there is provided a filter assembly comprising a plastics housing providing an inlet port and an outlet port, the material of the housing being such that the assembly can be sterilized by subjecting the interior of the housing to steam under pressure while the exterior of the housing is at atmospheric pressure without damaging the housing, a filter element held in the housing and comprising a filter medium of water wettable material having a central passage extending between first and second ends of the filter medium, the first end of the filter medium being embedded in a first end cap of a plastics material to close said passage and the second end of the filter medium being embedded in a second end cap of a plastics material, said second end cap providing a fluid connection between said passage and one of said ports, the first and second end caps forming respective water-wettable joints with the filter medium.

By end capping both ends of the filter medium, water wettable joints can be produced and a different material used for the housing that is steam sterilizable in situ.

5  According to a second aspect of the invention, there is provided a filter assembly comprising a housing having an inlet and an outlet and a filter element that is integrity testable by the Diffusive Forward Flow Test or the Water Bubble Point Test, that is held in the housing and that comprises a filter medium having a central passage extending between first and second ends of the filter medium, the housing being formed from a plastics material that is steam sterilizable.

10
15 It is also a problem with such filter assemblies in providing valves for the inlet port and the outlet port. Such valves need to be capable of steam sterilization, and many are not.

20  According to a third aspect of the invention, there is provided a valve for a filter assembly comprising an annular sleeve surrounding a passage of generally circular cross-section, movement of said sleeve in one sense opening said valve and movement of said sleeve in a sense opposite said one sense closing said valve.

According to a fourth aspect of the invention there is provided a valve comprising a part defining a cylindrical passage and a valve member movable between a first position in which the member sits in and seals against the circumference of the passage to close the valve and a second position in which the member is located out of the passage to open the valve.

The following is a more detailed description of an embodiment of the invention, by way of example, reference being made to the accompanying drawings in which:-

Figure 1 is an exploded view of a filter assembly showing first and second parts of a filter housing, a filter element within the housing and valves connected to inlet and drainage ports of the housing,

Figure 2 is a cross-section on the axis of the housing of Figure 1, showing one valve in an open position and a second valve in a closed position,

Figure 3 is detail B of Figure 2 showing the open valve to a larger scale, and

Figure 4 is detail C of Figure 2 showing the closed valve to a larger scale.

Referring to the drawings, and particularly Figure 1, the filter assembly comprises a housing indicated generally at 10, a filter element 11 encapsulated in the housing 10 and two valves 12 carried by the housing 10.

The housing 10 comprises a first housing part 13 and a second housing part 14. Both parts are made, for example moulded, from a polysulphone material. The first housing part 13 includes an end wall 15 provided with an inlet port 16 for the medium to be filtered, and a circular cross-section side wall 17 extending downwardly from the end wall 15 and terminating at a circular edge 18. An outwardly facing annular rebate 19 is formed in the side wall 17 adjacent the edge.

An air vent port 20 is formed at the junction between the end wall 15 and the side wall 17 and extends in a direction generally radially relative to the axis 21 (see Figure 2) of the housing 10. The inner surface 60 of the air vent port 20 defines a passage having a smaller diameter portion 22 closer to the side wall 17 and a larger diameter portion 23 further from the side wall 17 and terminating at the end of the air vent port 20. Five ribs 61 extend into the larger diameter

portion 23 from the inner surface 60. The ribs 61 are spaced equi-angularly around the surface 60. Each rib 61 has an edge 62 that is continuous and in line with the inner surface 60 at the small diameter portion of the passage.

5

The air vent port 20 has an exterior surface 24 provided with an annular groove 25 adjacent the end of the port 20 which carries an O-ring seal 26. In addition, this surface 24 has two pins 27 projecting radially from the surface at respective positions on the surface spaced from the end of the port 20. The function of the seal 26 and the pins 27 is described below.

The second housing part 14 includes a second end wall 28 provided with a disc-shaped stand 29. The second end wall 28 has its end remote from the stand of generally annular shape coaxial with the axis 21 of the housing 10. This portion of the second end wall 28 is provided with an inwardly facing rebate 30.

20


As best seen in Figure 2, the second end wall 28 has an outlet port 31 in the form of a generally circular cross-section passage co-axial with the axis 21 of the housing 10 and extending through the second end wall 28 and the stand 29.

The end of the outlet port 31 within the housing 10 forms an annular flange 32.

5 A drainage port 33 is provided in the second end wall 28 and extends radially from the second end wall 28 relative to the axis 21 of the housing 10. The drainage port 33 is constructed similarly to the air vent port 20 (parts common to the two ports 20,33 are given the same reference numerals and will not be described in detail).

10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200
205
210
215
220
225
230
235
240
245
250
255
260
265
270
275
280
285
290
295
300
305
310
315
320
325
330
335
340
345
350
355
360
365
370
375
380
385
390
395
400
405
410
415
420
425
430
435
440
445
450
455
460
465
470
475
480
485
490
495
500
505
510
515
520
525
530
535
540
545
550
555
560
565
570
575
580
585
590
595
600
605
610
615
620
625
630
635
640
645
650
655
660
665
670
675
680
685
690
695
700
705
710
715
720
725
730
735
740
745
750
755
760
765
770
775
780
785
790
795
800
805
810
815
820
825
830
835
840
845
850
855
860
865
870
875
880
885
890
895
900
905
910
915
920
925
930
935
940
945
950
955
960
965
970
975
980
985
990
995
1000
1005
1010
1015
1020
1025
1030
1035
1040
1045
1050
1055
1060
1065
1070
1075
1080
1085
1090
1095
1100
1105
1110
1115
1120
1125
1130
1135
1140
1145
1150
1155
1160
1165
1170
1175
1180
1185
1190
1195
1200
1205
1210
1215
1220
1225
1230
1235
1240
1245
1250
1255
1260
1265
1270
1275
1280
1285
1290
1295
1300
1305
1310
1315
1320
1325
1330
1335
1340
1345
1350
1355
1360
1365
1370
1375
1380
1385
1390
1395
1400
1405
1410
1415
1420
1425
1430
1435
1440
1445
1450
1455
1460
1465
1470
1475
1480
1485
1490
1495
1500
1505
1510
1515
1520
1525
1530
1535
1540
1545
1550
1555
1560
1565
1570
1575
1580
1585
1590
1595
1600
1605
1610
1615
1620
1625
1630
1635
1640
1645
1650
1655
1660
1665
1670
1675
1680
1685
1690
1695
1700
1705
1710
1715
1720
1725
1730
1735
1740
1745
1750
1755
1760
1765
1770
1775
1780
1785
1790
1795
1800
1805
1810
1815
1820
1825
1830
1835
1840
1845
1850
1855
1860
1865
1870
1875
1880
1885
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
2060
2065
2070
2075
2080
2085
2090
2095
2100
2105
2110
2115
2120
2125
2130
2135
2140
2145
2150
2155
2160
2165
2170
2175
2180
2185
2190
2195
2200
2205
2210
2215
2220
2225
2230
2235
2240
2245
2250
2255
2260
2265
2270
2275
2280
2285
2290
2295
2300
2305
2310
2315
2320
2325
2330
2335
2340
2345
2350
2355
2360
2365
2370
2375
2380
2385
2390
2395
2400
2405
2410
2415
2420
2425
2430
2435
2440
2445
2450
2455
2460
2465
2470
2475
2480
2485
2490
2495
2500
2505
2510
2515
2520
2525
2530
2535
2540
2545
2550
2555
2560
2565
2570
2575
2580
2585
2590
2595
2600
2605
2610
2615
2620
2625
2630
2635
2640
2645
2650
2655
2660
2665
2670
2675
2680
2685
2690
2695
2700
2705
2710
2715
2720
2725
2730
2735
2740
2745
2750
2755
2760
2765
2770
2775
2780
2785
2790
2795
2800
2805
2810
2815
2820
2825
2830
2835
2840
2845
2850
2855
2860
2865
2870
2875
2880
2885
2890
2895
2900
2905
2910
2915
2920
2925
2930
2935
2940
2945
2950
2955
2960
2965
2970
2975
2980
2985
2990
2995
3000
3005
3010
3015
3020
3025
3030
3035
3040
3045
3050
3055
3060
3065
3070
3075
3080
3085
3090
3095
3100
3105
3110
3115
3120
3125
3130
3135
3140
3145
3150
3155
3160
3165
3170
3175
3180
3185
3190
3195
3200
3205
3210
3215
3220
3225
3230
3235
3240
3245
3250
3255
3260
3265
3270
3275
3280
3285
3290
3295
3300
3305
3310
3315
3320
3325
3330
3335
3340
3345
3350
3355
3360
3365
3370
3375
3380
3385
3390
3395
3400
3405
3410
3415
3420
3425
3430
3435
3440
3445
3450
3455
3460
3465
3470
3475
3480
3485
3490
3495
3500
3505
3510
3515
3520
3525
3530
3535
3540
3545
3550
3555
3560
3565
3570
3575
3580
3585
3590
3595
3600
3605
3610
3615
3620
3625
3630
3635
3640
3645
3650
3655
3660
3665
3670
3675
3680
3685
3690
3695
3700
3705
3710
3715
3720
3725
3730
3735
3740
3745
3750
3755
3760
3765
3770
3775
3780
3785
3790
3795
3800
3805
3810
3815
3820
3825
3830
3835
3840
3845
3850
3855
3860
3865
3870
3875
3880
3885
3890
3895
3900
3905
3910
3915
3920
3925
3930
3935
3940
3945
3950
3955
3960
3965
3970
3975
3980
3985
3990
3995
4000
4005
4010
4015
4020
4025
4030
4035
4040
4045
4050
4055
4060
4065
4070
4075
4080
4085
4090
4095
4100
4105
4110
4115
4120
4125
4130
4135
4140
4145
4150
4155
4160
4165
4170
4175
4180
4185
4190
4195
4200
4205
4210
4215
4220
4225
4230
4235
4240
4245
4250
4255
4260
4265
4270
4275
4280
4285
4290
4295
4300
4305
4310
4315
4320
4325
4330
4335
4340
4345
4350
4355
4360
4365
4370
4375
4380
4385
4390
4395
4400
4405
4410
4415
4420
4425
4430
4435
4440
4445
4450
4455
4460
4465
4470
4475
4480
4485
4490
4495
4500
4505
4510
4515
4520
4525
4530
4535
4540
4545
4550
4555
4560
4565
4570
4575
4580
4585
4590
4595
4600
4605
4610
4615
4620
4625
4630
4635
4640
4645
4650
4655
4660
4665
4670
4675
4680
4685
4690
4695
4700
4705
4710
4715
4720
4725
4730
4735
4740
4745
4750
4755
4760
4765
4770
4775
4780
4785
4790
4795
4800
4805
4810
4815
4820
4825
4830
4835
4840
4845
4850
4855
4860
4865
4870
4875
4880
4885
4890
4895
4900
4905
4910
4915
4920
4925
4930
4935
4940
4945
4950
4955
4960
4965
4970
4975
4980
4985
4990
4995
5000
5005
5010
5015
5020
5025
5030
5035
5040
5045
5050
5055
5060
5065
5070
5075
5080
5085
5090
5095
5100
5105
5110
5115
5120
5125
5130
5135
5140
5145
5150
5155
5160
5165
5170
5175
5180
5185
5190
5195
5200
5205
5210
5215
5220
5225
5230
5235
5240
5245
5250
5255
5260
5265
5270
5275
5280
5285
5290
5295
5300
5305
5310
5315
5320
5325
5330
5335
5340
5345
5350
5355
5360
5365
5370
5375
5380
5385
5390
5395
5400
5405
5410
5415
5420
5425
5430
5435
5440
5445
5450
5455
5460
5465
5470
5475
5480
5485
5490
5495
5500
5505
5510
5515
5520
5525
5530
5535
5540
5545
5550
5555
5560
5565
5570
5575
5580
5585
5590
5595
5600
5605
5610
5615
5620
5625
5630
5635
5640
5645
5650
5655
5660
5665
5670
5675
5680
5685
5690
5695
5700
5705
5710
5715
5720
5725
5730
5735
5740
5745
5750
5755
5760
5765
5770
5775
5780
5785
5790
5795
5800
5805
5810
5815
5820
5825
5830
5835
5840
5845
5850
5855
5860
5865
5870
5875
5880
5885
5890
5895
5900
5905
5910
5915
5920
5925
5930
5935
5940
5945
5950
5955
5960
5965
5970
5975
5980
5985
5990
5995
6000
6005
6010
6015
6020
6025
6030
6035
6040
6045
6050
6055
6060
6065
6070
6075
6080
6085
6090
6095
6100
6105
6110
6115
6120
6125
6130
6135
6140
6145
6150
6155
6160
6165
6170
6175
6180
6185
6190
6195
6200
6205
6210
6215
6220
6225
6230
6235
6240
6245
6250
6255
6260
6265
6270
6275
6280
6285
6290
6295
6300
6305
6310
6315
6320
6325
6330
6335
6340
6345
6350
6355
6360
6365
6370
6375
6380
6385
6390
6395
6400
6405
6410
6415
6420
6425
6430
6435
6440
6445
6450
6455
6460
6465
6470
6475
6480
6485
6490
6495
6500
6505
6510
6515
6520
6525
6530
6535
6540
6545
6550
6555
6560
6565
6570
6575
6580
6585
6590
6595
6600
6605
6610
6615
6620
6625
6630
6635
6640
6645
6650
6655
6660
6665
6670
6675
6680
6685
6690
6695
6700
6705
6710
6715
6720
6725
6730
6735
6740
6745
6750
6755
6760
6765
6770
6775
6780
6785
6790
6795
6800
6805
6810
6815
6820
6825
6830
6835
6840
6845
6850
6855
6860
6865
6870
6875
6880
6885
6890
6895
6900
6905
6910
6915
6920
6925
6930
6935
6940
6945
6950
6955
6960
6965
6970
6975
6980
6985
6990
6995
7000
7005
7010
7015
7020
7025
7030
7035
7040
7045
7050
7055
7060
7065
7070
7075
7080
7085
7090
7095
7100
7105
7110
7115
7120
7125
7130
7135
7140
7145
7150
7155
7160
7165
7170
7175
7180
7185
7190
7195
7200
7205
7210
7215
7220
7225
7230
7235
7240
7245
7250
7255
7260
7265
7270
7275
7280
7285
7290
7295
7300
7305
7310
7315
7320
7325
7330
7335
7340
7345
7350
7355
7360
7365
7370
7375
7380
7385
7390
7395
7400
7405
7410
7415
7420
7425
7430
7435
7440
7445
7450
7455
7460
7465
7470
7475
7480
7485
7490
7495
7500
7505
7510
7515
7520
7525
7530
7535
7540
7545
7550
7555
7560
7565
7570
7575
7580
7585
7590
7595
7600
7605
7610
7615
7620
7625
7630
7635
7640
7645
7650
7655
7660
7665
7670
7675
7680
7685
7690
7695
7700
7705
7710
7715
7720
7725
7730
7735
7740
7745
7750
7755
7760
7765
7770
7775
7780
7785
7790
7795
7800
7805
7810
7815
7820
7825
7830
7835
7840
7845
7850
7855
7860
7865
7870
7875
7880
7885
7890
7895
7900
7905
7910
7915
7920
7925
7930
7935
7940
7945
7950
7955
7960
7965
7970
7975
7980
7985
7990
7995
8000
8005
8010
8015
8020
8025
8030
8035
8040
8045
8050
8055
8060
8065
8070
8075
8080
8085
8090
8095
8100
8105
8110
8115
8120
8125
8130
8135
8140
8145
8150
8155
8160
8165
8170
8175
8180
8185
8190
8195
8200
8205
8210
8215
8220
8225
8230
8235
8240
8245
8250
8255
8260
8265
8270
8275
8280
8285
8290
8295
8300
8305
8310
8315
8320
8325
8330
8335
8340
8345
8350
8355
8360
8365
8370
8375
8380
8385
8390
8395
8400
8405
8410
8415
8420
8425
8430
8435
8440
8445
8450
8455
8460
8465
8470
8475
8480
8485
8490
8495
8500
8505
8510
8515
8520
8525
8530
8535
8540
8545
8550
8555
8560
8565
8570
8575
8580
8585
8590
8595
8600
8605
8610
8615
8620
8625
8630
8635
8640
8645
8650
8655
8660
8665
8670
8675
8680
8685
8690
8695
8700
8705
8710
8715
8720
8725
8730
8735
8740
8745
8750
8755
8760
8765
8770
8775
8780
8785
8790
8795
8800
8805
8810
8815
8820
8825
8830
8835
8840
8845
8850
8855
8860
8865
8870
8875
8880
8885
8890
8895
8900
8905
8910
8915
8920
8925
8930
8935
8940
8945
8950
8955
8960
8965
8970
8975
8980
8985
8990
8995
9000
9005
9010
9015
9020
9025
9030
9035
9040
9045
9050
9055
9060
9065
9070
9075
9080
9085
9090
9095
9100
9105
9110
9115
9120
9125
9130
9135
9140
9145
9150
9155
9160
9165
9170
9175
9180
9185
9190
9195
9200
9205
9210
9215
9220
9225
9230
9235
9240
9245
9250
9255
9260
9265
9270
9275
9280
9285
9290
9295
9300
9305
9310
9315
9320
9325
9330
9335
9340
9345
9350
9355
9360
9365
9370
9375
9380
9385
9390
9395
9400
9405
9410
9415
9420
9425
9430
9435
9440
9445
9450
9455
9460
9465
9470
9475
9480
9485
9490
9495
9500
9505
9510
9515
9520
9525
9530
9535
9540
9545
9550
9555
9560
9565
9570
9575
9580
9585
9590
9595
9600
9605
9610
9615
9620
9625
9630
9635
9640
9645
9650
9655
9660
9665
9670
9675
9680
9685
9690
9695
9700
9705
9710
9715
9720
9725
9730
9735
9740
9745
9750
9755
9760
9765
9770
9775
9780
9785
9790
9795
9800
9805
9810
9815
9820
9825
9830
9835
9840
9845
9850
9855
9860
9865
9870
9875
9880
9885
9890
9895
9900
9905
9910
9915
9920
9925
9930
9935
9940
9945
9950
9955
9960
9965
9970
9975
9980
9985
9990
9995
10000
10005
10010
10015
10020
10025
10030
10035
10040
10045
10050
10055
10060
10065
10070
10075
10080
10085
10090
10095
10100
10105
10110
10115
10120
10125
10130
10135
10140
10145
10150
10155
10160
10165
10170
10175
10180
10185
10190
10195
10200
10205
1021

cap 35 and then inserting the filter medium into the softened end cap material to form a joint.

5  The material of the first end cap 35 is chosen so that, when the filter medium 34 is connected to the first end cap 35, the characteristics of the medium 34 are not materially changed. In particular, when the filter medium 34 is of a water-wettable material, the material of the first end cap is chosen to that a water wettable joint is formed between the filter medium 34 and the first end cap 35. In this case, the end cap material will depend on the material of the filter medium 34. For example, when the filter medium 34 is a FLUORODYNE or SUPOR medium, the end cap 35 may be composed of polypropylene. When the filter medium 34 is composed of a nylon material the first end cap 35 may be composed of a polyester or nylon material.

20 It is important to obtain a water-wettable joint between water-wettable filter media and the first end cap 35 in order to allow the filter element to be integrity tested. An integrity test involves the filter element being placed in a bath of water (with the ends of the passage closed) and air is then supplied to the passage at increasing pressure. The bath is then observed to determine at what pressure the first
25 bubble appears on the exterior of the filter medium. If the

porous structure of the filter medium is integral over the whole area of the filter medium, then the first bubble will appear at a relatively high pressure. If, however, the porous structure is not integral over the whole area of the filter medium 34, then the first bubble will appear at a relatively lower pressure. If the junction between the first end cap 35 and the filter medium 34 is not water-wettable, it creates a hydrophobic zone through which air passes readily since the porous structure is not wetted out by water. Although this does not normally affect filtration during use of the assembly, it is not possible to test the integrity as described above. The formation of hydrophobic zones similarly prevents the medium being tested by the Diffusive Forward Flow Test described above.

Where the filter medium 34 is hydrophobic, it is important to ensure that the first end cap 35 is composed of a material that can be softened at a temperature that is sufficiently low so that the integrity of the medium 35 is not damaged by the insertion process. For example, when the filter medium 34 is composed of PVDF (such as an EMFLON 2 medium) the first end cap 35 may be composed of polypropylene. Where the filter medium 35 is composed of PTFE, which is relatively resistant to heat, it is also preferable to use polypropylene end caps.

The second end cap 36 comprises a flat annular portion 38 with a central aperture. A projecting tube 39 surrounds the aperture and extends away from the filter medium 34 in a direction normal to the plane of the flat annular portion 38.

5 The tube 39 is provided with two annular seals 40 on its exterior surface 41. Four flanges 42 project radially outwardly of the flat annular portion 38 and are equi-angularly spaced around this portion 38.

10 The outer diameter of the tube 39 is generally equal to the interior diameter of the outlet port 31.

15 For any filter medium 34, the material of the second end cap is chosen based on the same considerations affecting the choice of the material of the first end cap. The material of the second end cap 36 will normally, but not necessarily, be the same as the material of the first end cap 35. The filter medium 34 is connected to the second end cap 36 by heating the second end cap 36 and then inserting the filter medium 34 into
20 the softened material. The cage 37, which is of known type, surrounds the exterior surface of the filter medium 34 between the first and second end caps 35,36.

25 The filter element 11 is mounted in the housing in the following way. First, the tube 39 on the second end cap 36 is

inserted into the outlet port 31 in the second end wall 28. The seals 40 prevent leakage between these parts. When fully inserted, the flange 32 of the outlet port 31 bears against the under-surface of the flat annular portion 38 of the second end cap 36. This holds the filter element 11 in the second end wall 28 coaxial with the housing axis 21. In addition, it connects the interior passage of the filter medium 34 with the outlet port 31 via the tube 39.

The first housing part 13 is then placed over the filter element 11 with the edge 18 fitting within the second end wall 28 and the rebate 19 adjacent this edge mating with the rebate 30 in the second end wall 28. The first and second housing parts 13,14 are then welded together around the rebates 19,30.

When so positioned, the edge 18 of the side wall 17 bears against the flanges 42. The effect of this is to clamp the filter element 11 between this edge 18 and the end of the flange 32 surrounding the outlet port 31 and contacting the second end cap 36. In this way, the filter element 11 is held firmly in position encapsulated in the housing 10.

Referring next to Figures 3 and 4 in particular, the valves 12 control flow through the air vent port 20 and the drainage

port 33. The valves 12 are identical and so only one of them will be described.

5 The valve 12 comprises an elongated valve member 43 which is generally circular in cross-section. The valve member 43 has a blind end 44 within the associated port. The blind end 44 carries an O-ring 45 in a groove provided on an exterior surface. The remainder of the valve member 43 has an axial passage 46 leading to a connector 47 for connection to a hose or pipe. In Figure 3 the connector 47 has an annular triangular-section rib 63 and in Figure 4 the connector 47 has a succession of axially spaced ribs 64. At least one radial passage 48 connects the end of the axial passage 46 adjacent the blind end 44 with the exterior surface of the valve member 43.

10 A sleeve 49 is arranged coaxially with the axis of the valve member 43 and is spaced from the valve member 43 by an annular radially extending flange 50. The sleeve 49 is a sliding fit over the exterior surface 24 of the associated port 20,31. In addition, the sleeve is provided with two helical slots 51 (seen best in Figure 1) extending around a portion of the sleeve 49. Each pin 27 is received in a respective one of the slots 51.

The sleeve 49 can thus be rotated relative to the associated port 20,33 with such rotation being controlled by the engagement of the pin 27 in the slot 51 to cause the sleeve 49 also to move axially relative to the associated port 20,33.

5 This rotation can take place in both senses.

The effect of this rotation is best seen in Figures 3 and 4. At one limit of rotation in one sense, as seen in Figure 3, the blind end 44 of the valve member 43 lies in the larger diameter portion 23 of the associated port 20,33. When so positioned, the valve member 43, and the associated O-ring 45, do not obstruct the port and so allow flow into the port, through the radial passage 48 and along the axial passage 46. Reverse flow is, of course, also possible. Leakage around the sleeve 49 is prevented by the O-ring seal 26 on the exterior surface 24 of the port 20,33. The O-ring 45 is kept pressed into the groove on the outer surface of the blind end by the ribs 61 - the edges 62 bearing against the O-ring 45.

20 Rotation of the sleeve 49 in the opposite sense moves the blind end 44 into the smaller diameter portion. The O-ring 45 is guided into the smaller diameter portion by the edges 62. Maximum rotation in the opposite sense disposes the valve member as shown in Figure 4. In this disposition, the blind
25 end 44 lies within the smaller diameter portion 22 of the

associated port 20, 33. The O-ring 45 seals against the inner surface 60 of the port 20, 33 so preventing flow through the valve. It will be appreciated that because the seal is made against the circumference of the smaller portion 22 (and not, for example, against a radially extending seat) the port 20, 33 and the valve member 43 can undergo differential expansion during heating without causing damage to the valve as the blind end 44 simply moves axially with the small portion 22.

Thus, by twisting the sleeve 49 in one sense or the other, the associated port 20, 33 can be opening or closed. It will also be appreciated that the pin 27 and slot 51 mechanism prevents the valve 12 being disengaged completely from the associated port 20, 33.

The valves 12 are preferably made from a polysulphone material.

The housing parts 13, 14 and the valves 12 may also be made from any other suitable plastics material capable of withstanding in-line sterilization. As stated above, in-line sterilization involves passing steam under pressure through the housing. The exterior of the housing is kept at atmospheric pressure and so there is a pressure differential across the housing. The minimum temperature and pressure of

steam commonly used for sterilization is generally about 121°C at about 1 bar above atmospheric pressure, although in some circumstances, in particular if exposure to the steam is prolonged, sterilization may be achievable at lower temperatures and pressures. However, it is often desirable to sterilize the assembly in-line under harsher conditions, for example using steam at about 142°C and about 2.83 bar above atmospheric pressure. The housing is preferably resistant to such harsher conditions. Examples of plastics other than polysulphone that are suitable are PEEK, PEK, polyphenyleneoxide, polyphenylenesulphide, polyethersulphone polyalkoxysulphone and polyarylsulphone.

In use, the filter assembly described above with reference to the drawings is mounted in a line containing a fluid to be filtered. This may be, for example, a medical, biomedical or pharmaceutical fluid. A tube leading from a source of fluid to be filtered is connected to the inlet 16. The outlet port 31 is connected to a receiver of filtered fluid. The drainage port 33 is connected to a tube leading to a receiver for drained fluid. The valve 12 of the air vent port 20 is opened and the valve 12 of the drainage port 33 is closed. Fluid to be filtered is then fed through the inlet 16 to fill the housing 10. The air vent port 20 is then shut. The fluid

passes through the filter medium 34 where it is filtered and the filtered fluid enters the passage before passing through the tube 39 and the outlet port 31.

5 When the filter assembly is to be sterilized, the inlet 16 is disconnected from the supply of fluid to be filtered and the outlet port 31 is disconnected from the receiver of filtered fluid. The drainage port valve 12 is open to drain excess fluid from the housing 10. The inlet 16 is then connected to a supply of steam under pressure and the outlet port 31 is connected to a drain. The valves 12 are left slightly open. Steam at the pressure of several bars and a temperature of about 140°C is then fed through the housing to steam sterilize the filter material 34 and the other components. The housing 10, since it is made of polysulphone (or another suitable plastics material), is able to withstand the temperature and pressure of the steam. The same is true of the valves 12; because they are made of polysulphone (or another suitable plastics material), they will withstand the in-line steam sterilization without damage.

Once steam sterilization is complete, water can be drained by fully opening the drainage port valve 12 and the filter assembly reconnected for filtering fluid.

By separating the caps 35,36 from the housing 10, these parts can be made in different materials to provide the water wettability necessary for the filter medium 34 and the resistance to in-line steam sterilization necessary for the housing 10.

It will be appreciated that there are a number of modifications that can be made to the arrangement described above.

The valves 12 need not be as described above. Any suitable valves could be used. The plastics material of the housing 10 need not be polysulphone, it could be any material that is capable of withstanding in-line steam sterilization. The filter element 11 need not be clamped in the housing 10 as described, it could be held in any suitable way. The cage 37 need not be as described, any suitable cage could be provided. The filter medium 34 may be provided with upstream and/or downstream drainage layers.